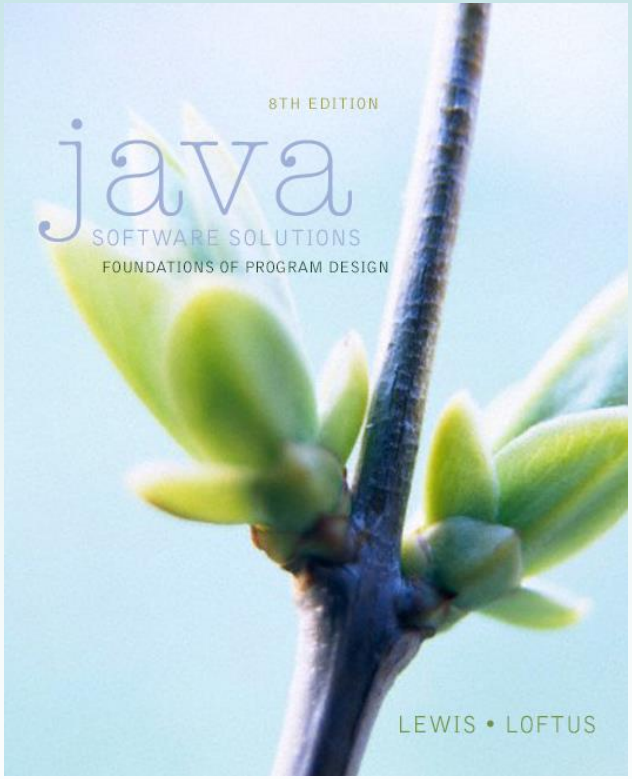
Chapter 3
Using Classes and Objects



Java Software Solutions
Foundations of Program Design
8th Edition

John Lewis
William Loftus

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Using Classes and Objects

- We can create more interesting programs using predefined classes and related objects
- Chapter 3 focuses on:
  - object creation and object references
  - the `String` class and its methods
  - the Java API class library
  - the `Random` and `Math` classes
  - formatting output
  - enumerated types
  - wrapper classes
  - graphical components and containers
  - labels and images

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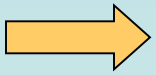
Outline



Creating Objects

The String Class

The Random and Math Classes

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Components and Containers

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Creating Objects

- A variable holds either a primitive value or a *reference* to an object
- A class name can be used as a type to declare an *object reference variable*

```
String title;
```

- No object is created with this declaration
- An object reference variable holds the address of an object
- The object itself must be created separately

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Creating Objects

- Generally, we use the `new` operator to create an object
- Creating an object is called *instantiation*
- An object is an *instance* of a particular class

```
title = new String("Java Software Solutions");
```

This calls the String *constructor*, which is a special method that sets up the object

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Invoking Methods

- We've seen that once an object has been instantiated, we can use the *dot operator* to invoke its methods

```
numChars = title.length()
```

- A method may *return a value*, which can be used in an assignment or expression

- A method invocation can be thought of as asking an object to perform a service

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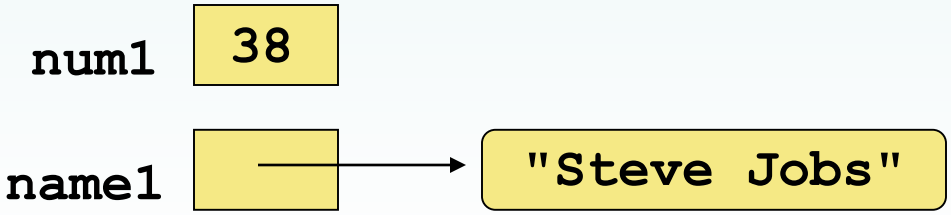
References

- Note that a primitive variable contains the value itself, but an object variable contains the address of the object
- An object reference can be thought of as a pointer to the location of the object
- Rather than dealing with arbitrary addresses, we often depict a reference graphically



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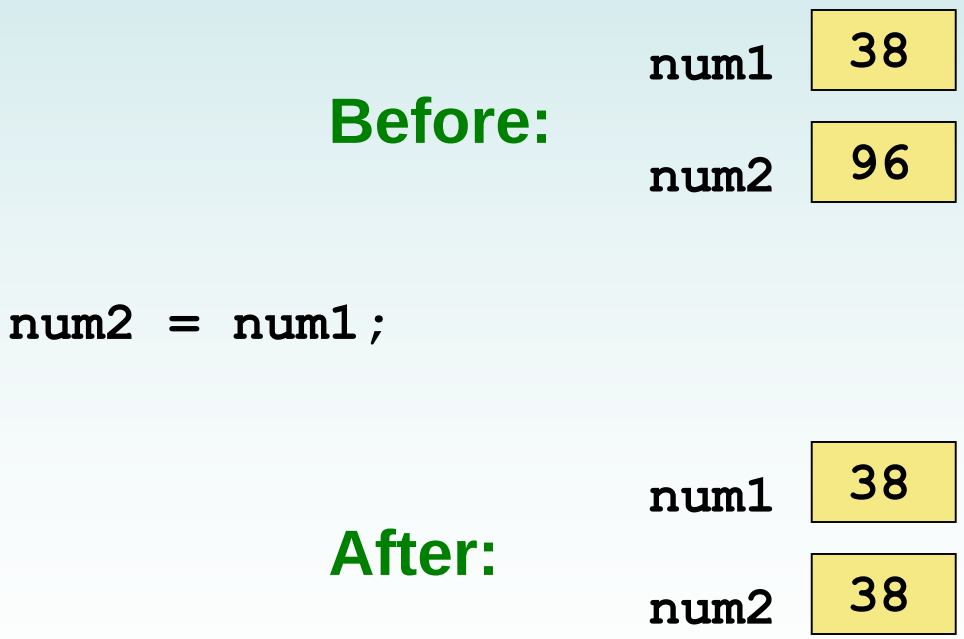
Assignment Revisited

- The act of assignment takes a copy of a value and stores it in a variable
- For primitive types:



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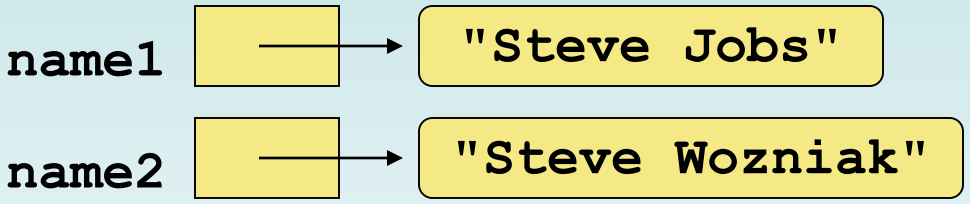
Reference Assignment

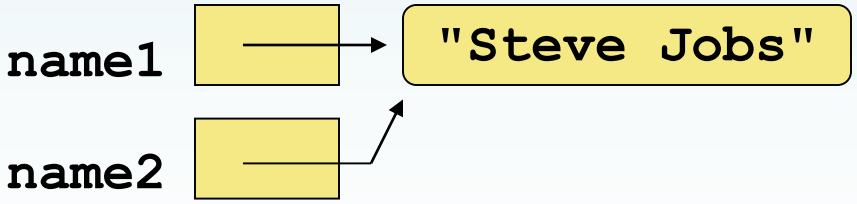
- For object references, assignment copies the address:

Before:




```
name2 = name1;
```

After:



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Aliases

- Two or more references that refer to the same object are called *aliases* of each other
- That creates an interesting situation: one object can be accessed using multiple reference variables
- Aliases can be useful, but should be managed carefully
- Changing an object through one reference changes it for all of its aliases, because there is really only one object

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Garbage Collection

- When an object no longer has any valid references to it, it can no longer be accessed by the program
- The object is useless, and therefore is called *garbage*
- Java performs *automatic garbage collection* periodically, returning an object's memory to the system for future use
- In other languages, the programmer is responsible for performing garbage collection

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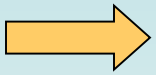
Outline



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The Random and Math Classes

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Components and Containers

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The String Class

- Because strings are so common, we don't have to use the `new` operator to create a `String` object

```
title = "Java Software Solutions";
```

- This is special syntax that works only for strings
- Each string literal (enclosed in double quotes) represents a `String` object

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String Methods

- Once a `String` object has been created, neither its value nor its length can be changed
- Therefore we say that an object of the `String` class is *immutable*
- However, several methods of the `String` class return new `String` objects that are modified versions of the original

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String Indexes

- It is occasionally helpful to refer to a particular character within a string
- This can be done by specifying the character's numeric *index*
- The indexes begin at zero in each string
- In the string `"Hello"`, the character `'H'` is at index 0 and the `'o'` is at index 4
- See `StringMutation.java`

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```
//********************************************************************
//  StringMutation.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the String class and its methods.
//********************************************************************

public class StringMutation
{
   //-----------------------------------------------------------------
   //  Prints a string and various mutations of it.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      String phrase = "Change is inevitable";
      String mutation1, mutation2, mutation3, mutation4;

      System.out.println("Original string: \"" + phrase + "\"");
      System.out.println("Length of string: " + phrase.length());

      mutation1 = phrase.concat(", except from vending machines.");
      mutation2 = mutation1.toUpperCase();
      mutation3 = mutation2.replace('E', 'X');
      mutation4 = mutation3.substring(3, 30);
```

continued

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continued

```
        // Print each mutated string
        System.out.println("Mutation #1: " + mutation1);
        System.out.println("Mutation #2: " + mutation2);
        System.out.println("Mutation #3: " + mutation3);
        System.out.println("Mutation #4: " + mutation4);

        System.out.println("Mutated length: " + mutation4.length());
    }
}
```

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Output

```
Original string: "Change is inevitable"
Length of string: 20
Mutation #1: Change is inevitable, except from vending machines.
Mutation #2: CHANGE IS INEVITABLE, EXCEPT FROM VENDING MACHINES.
Mutation #3: CHANGX IS INXVITABLX, XXCXPT FROM VXNDING MACHINXS.
Mutation #4: NGX IS INXVITABLX, XXCXPT F
Mutated length: 27
```

```
        System.out.println("Mutated length: " + mutation4.length());
    }
}
```

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Quick Check

What output is produced by the following?

```
String str = "Space, the final frontier.";
System.out.println(str.length());
System.out.println(str.substring(7));
System.out.println(str.toUpperCase());
System.out.println(str.length());
```

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Quick Check

What output is produced by the following?

```
String str = "Space, the final frontier.";
System.out.println(str.length());
System.out.println(str.substring(7));
System.out.println(str.toUpperCase());
System.out.println(str.length());
```

```
26
the final frontier.
SPACE, THE FINAL FRONTIER.
26
```

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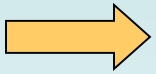
Outline



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Class Libraries

- A *class library* is a collection of classes that we can use when developing programs
- The *Java standard class library* is part of any Java development environment
- Its classes are not part of the Java language per se, but we rely on them heavily
- Various classes we've already used (`System`, `Scanner`, `String`) are part of the Java standard class library

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The Java API

- The Java class library is sometimes referred to as the Java API
- API stands for Application Programming Interface
- Clusters of related classes are sometimes referred to as specific APIs:
  - The Swing API
  - The Database API

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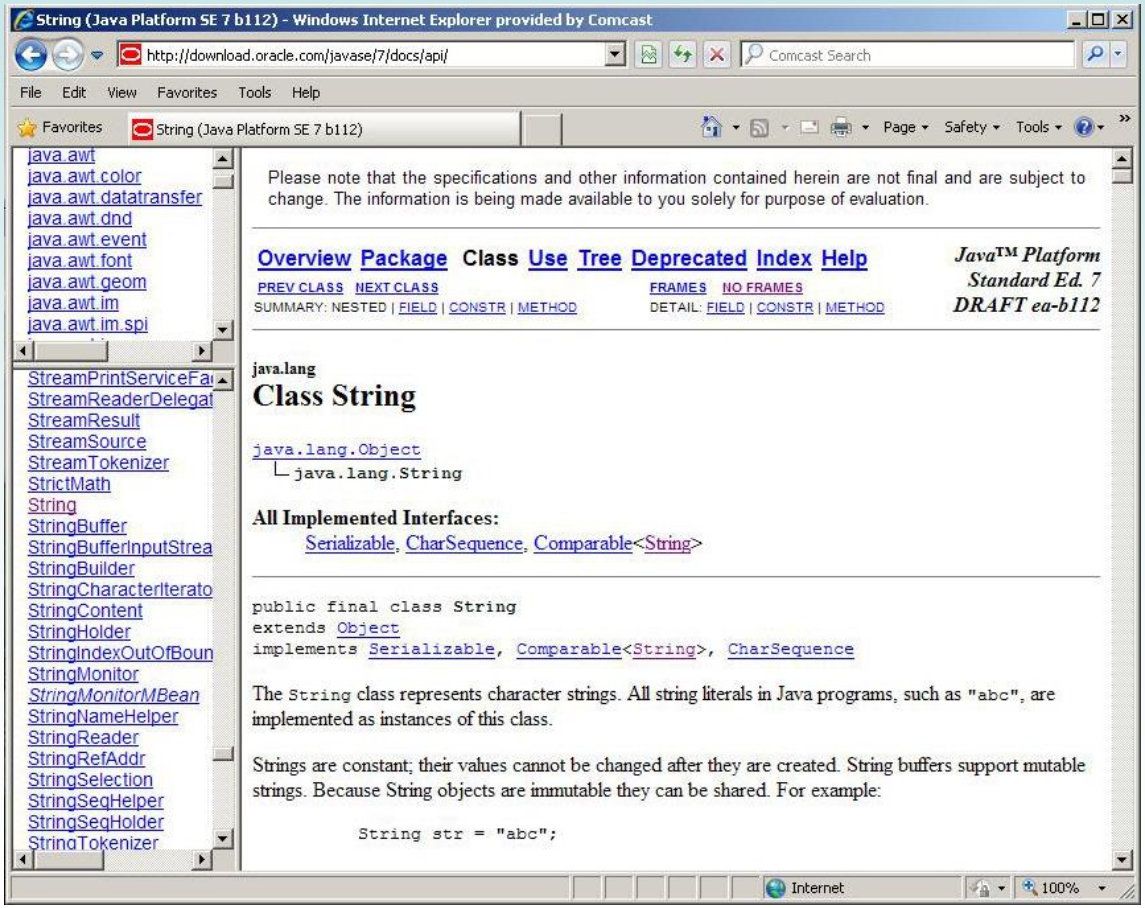
The Java API

- Get comfortable navigating the online Java API documentation



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Packages

- For purposes of accessing them, classes in the Java API are organized into *packages*
- These often overlap with specific APIs
- Examples:

Package	Purpose
java.lang	General support
java.applet	Creating applets for the web
java.awt	Graphics and graphical user interfaces
javax.swing	Additional graphics capabilities
java.net	Network communication
java.util	Utilities
javax.xml.parsers	XML document processing

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The import Declaration

- When you want to use a class from a package, you could use its *fully qualified name*

```
java.util.Scanner
```

- Or you can *import* the class, and then use just the class name

```
import java.util.Scanner;
```

- To import all classes in a particular package, you can use the * wildcard character

```
import java.util.*;
```

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The import Declaration

- All classes of the `java.lang` package are imported automatically into all programs
- It's as if all programs contain the following line:

```
import java.lang.*;
```

- That's why we didn't have to import the `System` or `String` classes explicitly in earlier programs
- The `Scanner` class, on the other hand, is part of the `java.util` package, and therefore must be imported

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The Random Class

- The `Random` class is part of the `java.util` package
- It provides methods that generate pseudorandom numbers
- A `Random` object performs complicated calculations based on a *seed value* to produce a stream of seemingly random values
- See `RandomNumbers.java`

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```
//********************************************************************
//  RandomNumbers.java       Author: Lewis/Loftus
//
//  Demonstrates the creation of pseudo-random numbers using the
//  Random class.
//********************************************************************

import java.util.Random;

public class RandomNumbers
{
   //-----------------------------------------------------------------
   //  Generates random numbers in various ranges.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      Random generator = new Random();
      int num1;
      float num2;

      num1 = generator.nextInt();
      System.out.println("A random integer: " + num1);

      num1 = generator.nextInt(10);
      System.out.println("From 0 to 9: " + num1);
```

continued

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continued

```
        num1 = generator.nextInt(10) + 1;
        System.out.println("From 1 to 10: " + num1);

        num1 = generator.nextInt(15) + 20;
        System.out.println("From 20 to 34: " + num1);

        num1 = generator.nextInt(20) - 10;
        System.out.println("From -10 to 9: " + num1);

        num2 = generator.nextFloat();
        System.out.println("A random float (between 0-1): " + num2);

        num2 = generator.nextFloat() * 6;  // 0.0 to 5.999999
        num1 = (int)num2 + 1;
        System.out.println("From 1 to 6: " + num1);
    }
}
```

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continued

```
        num1
        Syst

        num1
        Syst

        num1
        Syst

        num2 = generator.nextFloat();
        System.out.println("A random float (between 0-1): " + num2);

        num2 = generator.nextFloat() * 6;  // 0.0 to 5.999999
        num1 = (int)num2 + 1;
        System.out.println("From 1 to 6: " + num1);
    }
}
```

Sample Run

```
A random integer: 672981683
From 0 to 9: 0
From 1 to 10: 3
From 20 to 34: 30
From -10 to 9: -4
A random float (between 0-1): 0.18538326
From 1 to 6: 3
```

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Quick Check

Given a `Random` object named `gen`, what range of values are produced by the following expressions?

```
gen.nextInt(25)
gen.nextInt(6) + 1
gen.nextInt(100) + 10
gen.nextInt(50) + 100
gen.nextInt(10) – 5
gen.nextInt(22) + 12
```

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Quick Check

Given a `Random` object named `gen`, what range of values are produced by the following expressions?

	Range
`gen.nextInt(25)`	`0 to 24`
`gen.nextInt(6) + 1`	`1 to 6`
`gen.nextInt(100) + 10`	`10 to 109`
`gen.nextInt(50) + 100`	`100 to 149`
`gen.nextInt(10) – 5`	`-5 to 4`
`gen.nextInt(22) + 12`	`12 to 33`

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Quick Check

Write an expression that produces a random integer in the following ranges:

Range
`0 to 12`
`1 to 20`
`15 to 20`
`-10 to 0`

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Quick Check

Write an expression that produces a random integer in the following ranges:

Range	
0 to 12	`gen.nextInt(13)`
1 to 20	`gen.nextInt(20) + 1`
15 to 20	`gen.nextInt(6) + 15`
-10 to 0	`gen.nextInt(11) - 10`

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The Math Class

- The `Math` class is part of the `java.lang` package
- The `Math` class contains methods that perform various mathematical functions
- These include:
  - absolute value
  - square root
  - exponentiation
  - trigonometric functions

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The Math Class

- The methods of the `Math` class are *static methods* (also called *class methods*)
- Static methods are invoked through the class name – no object of the `Math` class is needed

```
value = Math.cos(90) + Math.sqrt(delta);
```

- We discuss static methods further in Chapter 7
- See `Quadratic.java`

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```
//********************************************************************
//  Quadratic.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the Math class to perform a calculation
//  based on user input.
//********************************************************************

import java.util.Scanner;

public class Quadratic
{
   //-----------------------------------------------------------------
   //  Determines the roots of a quadratic equation.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int a, b, c;  // ax^2 + bx + c
      double discriminant, root1, root2;

      Scanner scan = new Scanner(System.in);

      System.out.print("Enter the coefficient of x squared: ");
      a = scan.nextInt();
```

continued

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continued

```
        System.out.print("Enter the coefficient of x: ");
        b = scan.nextInt();

        System.out.print("Enter the constant: ");
        c = scan.nextInt();

        // Use the quadratic formula to compute the roots.
        // Assumes a positive discriminant.

        discriminant = Math.pow(b, 2) - (4 * a * c);
        root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
        root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

        System.out.println("Root #1: " + root1);
        System.out.println("Root #2: " + root2);
    }
}
```

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continued

```
        System
        b = sc

        System
        c = sc

        // Use the quadratic formula to compute the roots.
        // Assumes a positive discriminant.

        discriminant = Math.pow(b, 2) - (4 * a * c);
        root1 = ((-1 * b) + Math.sqrt(discriminant)) / (2 * a);
        root2 = ((-1 * b) - Math.sqrt(discriminant)) / (2 * a);

        System.out.println("Root #1: " + root1);
        System.out.println("Root #2: " + root2);
    }
}
```

Sample Run

```
Enter the coefficient of x squared: 3
Enter the coefficient of x: 8
Enter the constant: 4
Root #1: -0.6666666666666666
Root #2: -2.0
```

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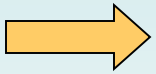

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Formatting Output

- It is often necessary to format output values in certain ways so that they can be presented properly
- The Java standard class library contains classes that provide formatting capabilities
- The `NumberFormat` class allows you to format values as currency or percentages
- The `DecimalFormat` class allows you to format values based on a pattern
- Both are part of the `java.text` package

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Formatting Output

- The `NumberFormat` class has static methods that return a formatter object

```
getCurrencyInstance()

getPercentInstance()
```

- Each formatter object has a method called `format` that returns a string with the specified information in the appropriate format
- See `Purchase.java`

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```
//********************************************************************
//  Purchase.java       Author: Lewis/Loftus
//
//  Demonstrates the use of the NumberFormat class to format output.
//********************************************************************

import java.util.Scanner;
import java.text.NumberFormat;

public class Purchase
{
   //-----------------------------------------------------------------
   //  Calculates the final price of a purchased item using values
   //  entered by the user.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      final double TAX_RATE = 0.06;  // 6% sales tax

      int quantity;
      double subtotal, tax, totalCost, unitPrice;

      Scanner scan = new Scanner(System.in);
```

continued

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continued

```
        NumberFormat fmt1 = NumberFormat.getCurrencyInstance();
        NumberFormat fmt2 = NumberFormat.getPercentInstance();

        System.out.print("Enter the quantity: ");
        quantity = scan.nextInt();

        System.out.print("Enter the unit price: ");
        unitPrice = scan.nextDouble();

        subtotal = quantity * unitPrice;
        tax = subtotal * TAX_RATE;
        totalCost = subtotal + tax;

        // Print output with appropriate formatting
        System.out.println("Subtotal: " + fmt1.format(subtotal));
        System.out.println("Tax: " + fmt1.format(tax) + " at "
                           + fmt2.format(TAX_RATE));
        System.out.println("Total: " + fmt1.format(totalCost));
    }
}
```

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continued

```
        NumberFormat f                                    tance();
        NumberFormat f                                    ance();

        System.out.pri
        quantity = sca

        System.out.print("Enter the unit price: ");
        unitPrice = scan.nextDouble();

        subtotal = quantity * unitPrice;
        tax = subtotal * TAX_RATE;
        totalCost = subtotal + tax;

        // Print output with appropriate formatting
        System.out.println("Subtotal: " + fmt1.format(subtotal));
        System.out.println("Tax: " + fmt1.format(tax) + " at "
                           + fmt2.format(TAX_RATE));
        System.out.println("Total: " + fmt1.format(totalCost));
    }
}
```

Sample Run

```
Enter the quantity: 5
Enter the unit price: 3.87
Subtotal: $19.35
Tax: $1.16 at 6%
Total: $20.51
```

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Formatting Output

- The `DecimalFormat` class can be used to format a floating point value in various ways
- For example, you can specify that the number should be truncated to three decimal places
- The constructor of the `DecimalFormat` class takes a string that represents a pattern for the formatted number
- See `CircleStats.java`

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```
//********************************************************************
//  CircleStats.java       Author: Lewis/Loftus
//
//  Demonstrates the formatting of decimal values using the
//  DecimalFormat class.
//********************************************************************

import java.util.Scanner;
import java.text.DecimalFormat;

public class CircleStats
{
   //-----------------------------------------------------------------
   //  Calculates the area and circumference of a circle given its
   //  radius.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      int radius;
      double area, circumference;

      Scanner scan = new Scanner(System.in);
```

continued

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continued

```
        System.out.print ("Enter the circle's radius: ");
        radius = scan.nextInt();

        area = Math.PI * Math.pow(radius, 2);
        circumference = 2 * Math.PI * radius;

        // Round the output to three decimal places
        DecimalFormat fmt = new DecimalFormat ("0.###");

        System.out.println ("The circle's area: " + fmt.format(area));
        System.out.println ("The circle's circumference: "
                            + fmt.format(circumference));
    }
}
```

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Sample Run

```
Enter the circle's radius: 5
The circle's area: 78.54
The circle's circumference: 31.416
```

continued

```
        System.ou
        radius =

        area = Math.PI * Math.pow(radius, 2);
        circumference = 2 * Math.PI * radius;

        // Round the output to three decimal places
        DecimalFormat fmt = new DecimalFormat("0.###");

        System.out.println("The circle's area: " + fmt.format(area));
        System.out.println("The circle's circumference: "
                           + fmt.format(circumference));
    }
}
```

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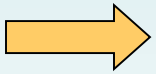

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Images

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Enumerated Types

- Java allows you to define an *enumerated type*, which can then be used to declare variables
- An enumerated type declaration lists all possible values for a variable of that type
- The values are identifiers of your own choosing
- The following declaration creates an enumerated type called `Season`

```
enum Season {winter, spring, summer, fall};
```

- Any number of values can be listed

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Enumerated Types

- Once a type is defined, a variable of that type can be declared:

```
Season time;
```

- And it can be assigned a value:

```
time = Season.fall;
```

- The values are referenced through the name of the type
- Enumerated types are *type-safe* – you cannot assign any value other than those listed

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Ordinal Values

- Internally, each value of an enumerated type is stored as an integer, called its *ordinal value*
- The first value in an enumerated type has an ordinal value of zero, the second one, and so on
- However, you cannot assign a numeric value to an enumerated type, even if it corresponds to a valid ordinal value

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Enumerated Types

- The declaration of an enumerated type is a special type of class, and each variable of that type is an object
- The `ordinal` method returns the ordinal value of the object
- The `name` method returns the name of the identifier corresponding to the object's value
- See `IceCream.java`

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```
//********************************************************************
//  IceCream.java       Author: Lewis/Loftus
//
//  Demonstrates the use of enumerated types.
//********************************************************************

public class IceCream
{
   enum Flavor {vanilla, chocolate, strawberry, fudgeRipple, coffee,
                rockyRoad, mintChocolateChip, cookieDough}

   //-----------------------------------------------------------------
   //  Creates and uses variables of the Flavor type.
   //-----------------------------------------------------------------
   public static void main (String[] args)
   {
      Flavor cone1, cone2, cone3;

      cone1 = Flavor.rockyRoad;
      cone2 = Flavor.chocolate;

      System.out.println("cone1 value: " + cone1);
      System.out.println("cone1 ordinal: " + cone1.ordinal());
      System.out.println("cone1 name: " + cone1.name());
```

continued

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continued

```
        System.out.println();
        System.out.println("cone2 value: " + cone2);
        System.out.println("cone2 ordinal: " + cone2.ordinal());
        System.out.println("cone2 name: " + cone2.name());

        cone3 = cone1;

        System.out.println();
        System.out.println("cone3 value: " + cone3);
        System.out.println("cone3 ordinal: " + cone3.ordinal());
        System.out.println("cone3 name: " + cone3.name());
    }
}
```

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continued

```
        System.out.prin
        System.out.prin                                    );
        System.out.prin                                 e2.ordinal());
        System.out.prin                                 name());

        cone3 = cone1;

        System.out.prin
        System.out.prin                                    );
        System.out.prin                                 e3.ordinal());
        System.out.println("cone3 name: " + cone3.name());
    }
}
```

Output

```
cone1 value: rockyRoad
cone1 ordinal: 5
cone1 name: rockyRoad
cone2 value: chocolate
cone2 ordinal: 1
cone2 name: chocolate
cone3 value: rockyRoad
cone3 ordinal: 5
cone3 name: rockyRoad
```

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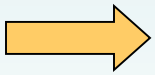

Wrapper Classes

Components and Containers

Images

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Wrapper Classes

- The `java.lang` package contains *wrapper classes* that correspond to each primitive type:

Primitive Type	Wrapper Class
`byte`	`Byte`
`short`	`Short`
`int`	`Integer`
`long`	`Long`
`float`	`Float`
`double`	`Double`
`char`	`Character`
`boolean`	`Boolean`

Wrapper Classes

- The following declaration creates an `Integer` object which represents the integer 40 as an object

```
Integer age = new Integer(40);
```

- An object of a wrapper class can be used in any situation where a primitive value will not suffice
- For example, some objects serve as containers of other objects
- Primitive values could not be stored in such containers, but wrapper objects could be

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Wrapper Classes

- Wrapper classes also contain static methods that help manage the associated type
- For example, the `Integer` class contains a method to convert an integer stored in a `String` to an `int` value:

```
num = Integer.parseInt(str);
```

- They often contain useful constants as well
- For example, the `Integer` class contains `MIN_VALUE` and `MAX_VALUE` which hold the smallest and largest `int` values

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Autoboxing

- *Autoboxing* is the automatic conversion of a primitive value to a corresponding wrapper object:

```
Integer obj;
int num = 42;
obj = num;
```

- The assignment creates the appropriate `Integer` object
- The reverse conversion (called *unboxing*) also occurs automatically as needed

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Quick Check

Are the following assignments valid? Explain.

```
Double value = 15.75;
```

```
Character ch = new Character('T');
char myChar = ch;
```

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Quick Check

Are the following assignments valid? Explain.

```
Double value = 15.75;
```

Yes. The double literal is autoboxed into a `Double` object.

```
Character ch = new Character('T');
char myChar = ch;
```

Yes, the char in the object is unboxed before the assignment.

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Graphical Applications

- Except for the applets seen in Chapter 2, the example programs we've explored thus far have been text-based
- They are called *command-line applications*, which interact with the user using simple text prompts
- Let's examine some Java applications that have graphical components
- These components will serve as a foundation to programs that have true graphical user interfaces (GUIs)

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GUI Components

- A *GUI component* is an object that represents a screen element such as a button or a text field
- GUI-related classes are defined primarily in the `java.awt` and the `javax.swing` packages
- The *Abstract Windowing Toolkit* (AWT) was the original Java GUI package
- The *Swing* package provides additional and more versatile components
- Both packages are needed to create a Java GUI-based program

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GUI Containers

- A *GUI container* is a component that is used to hold and organize other components
- A *frame* is a container displayed as a separate window with a title bar
- It can be repositioned and resized on the screen as needed
- A *panel* is a container that cannot be displayed on its own but is used to organize other components
- A panel must be added to another container (like a frame or another panel) to be displayed

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GUI Containers

- A GUI container can be classified as either heavyweight or lightweight
- A *heavyweight container* is one that is managed by the underlying operating system
- A *lightweight container* is managed by the Java program itself
- Occasionally this distinction is important
- A frame is a heavyweight container and a panel is a lightweight container

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Labels

- A *label* is a GUI component that displays a line of text and/or an image
- Labels are usually used to display information or identify other components in the interface
- Let's look at a program that organizes two labels in a panel and displays that panel in a frame
- This program is not interactive, but the frame can be repositioned and resized
- See `Authority.java`

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```
//********************************************************************
//  Authority.java       Author: Lewis/Loftus
//
//  Demonstrates the use of frames, panels, and labels.
//********************************************************************

import java.awt.*;
import javax.swing.*;

public class Authority
{
   //-----------------------------------------------------------------
   //  Displays some words of wisdom.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Authority");

      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      JPanel primary = new JPanel();
      primary.setBackground(Color.yellow);
      primary.setPreferredSize(new Dimension(250, 75));
```

continued

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continued

```
        JLabel label1 = new JLabel("Question authority,");
        JLabel label2 = new JLabel("but raise your hand first.");

        primary.add(label1);
        primary.add(label2);

        frame.getContentPane().add(primary);
        frame.pack();
        frame.setVisible(true);
    }
}
```

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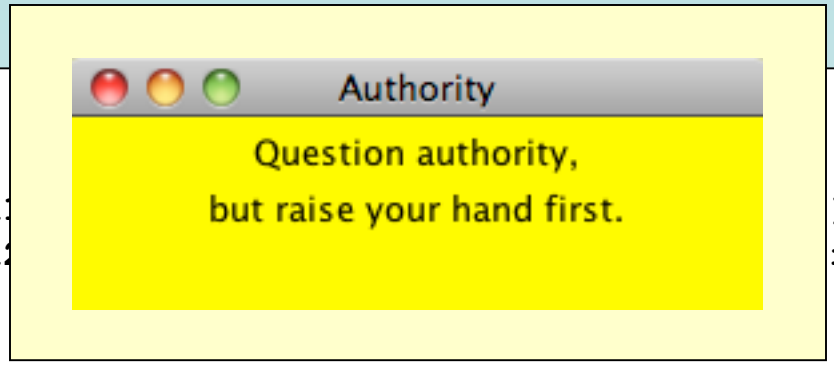
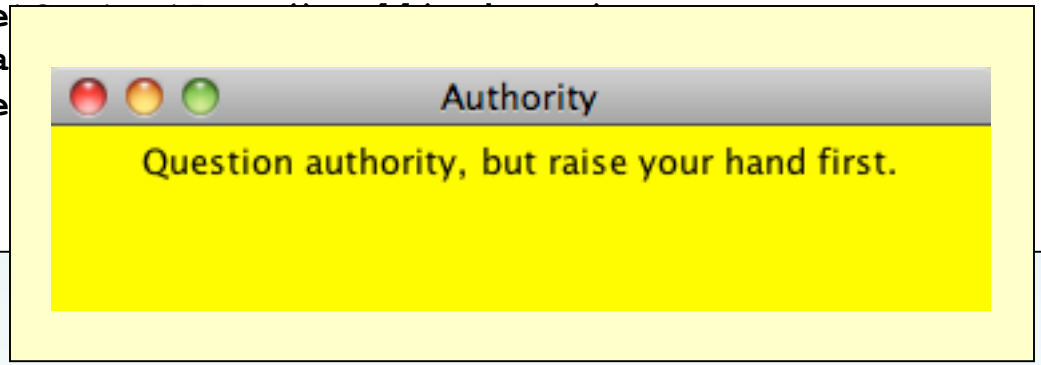
continued

```
        JLabel label1                                          );
        JLabel label2                                          first.");

        primary.add
        primary.add(label2);

        frame.ge
        frame.pa
        frame.se
    }
}
```





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Nested Panels

- Containers that contain other components make up the *containment hierarchy* of an interface
- This hierarchy can be as intricate as needed to create the visual effect desired
- The following example nests two panels inside a third panel – note the effect this has as the frame is resized
- See `NestedPanels.java`

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```
//********************************************************************
//  NestedPanels.java       Author: Lewis/Loftus
//
//  Demonstrates a basic componenet hierarchy.
//********************************************************************

import java.awt.*;
import javax.swing.*;

public class NestedPanels
{
   //-----------------------------------------------------------------
   //  Presents two colored panels nested within a third.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Nested Panels");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      // Set up first subpanel
      JPanel subPanel1 = new JPanel();
      subPanel1.setPreferredSize(new Dimension(150, 100));
      subPanel1.setBackground(Color.green);
      JLabel label1 = new JLabel("One");
      subPanel1.add(label1);
```

continued

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continued

```
        // Set up second subpanel
        JPanel subPanel2 = new JPanel();
        subPanel2.setPreferredSize(new Dimension(150, 100));
        subPanel2.setBackground(Color.red);
        JLabel label2 = new JLabel("Two");
        subPanel2.add(label2);

        // Set up primary panel
        JPanel primary = new JPanel();
        primary.setBackground(Color.blue);
        primary.add(subPanel1);
        primary.add(subPanel2);

        frame.getContentPane().add(primary);
        frame.pack();
        frame.setVisible(true);
    }
}
```

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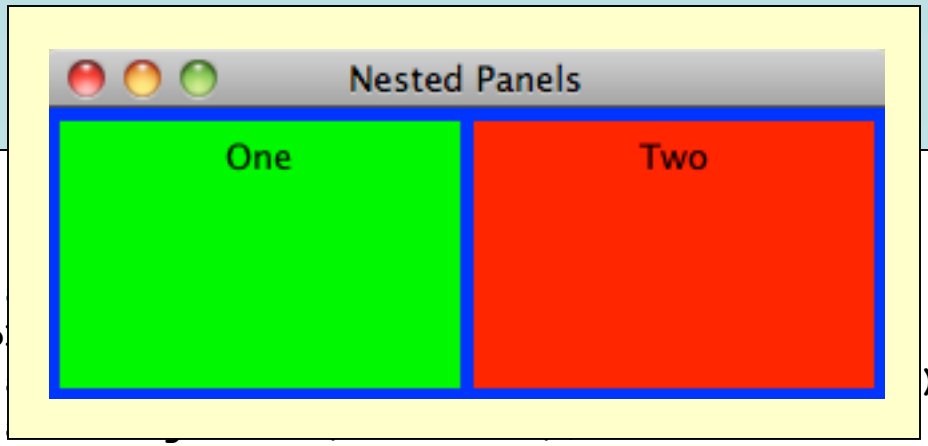
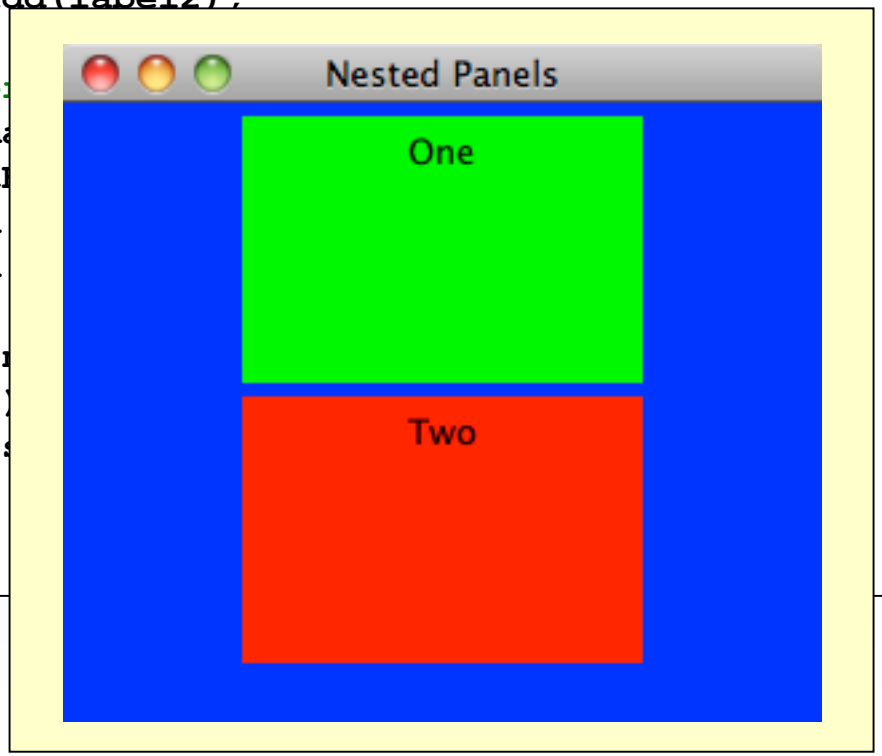
continued

```
        // Set up
        JPanel sub
        subPanel2.                                              );
        subPanel2.
        JLabel label2 = new JLabel("Two");
        subPanel2.add(label2);

        // Set up pr
        JPanel prima
        primary.setL
        primary.add
        primary.add

        frame.getCo
        frame.pack()
        frame.setVis
    }
}
```





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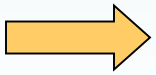

Images

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Images

- Images can be displayed in a Java program in various ways
- As we've seen, a `JLabel` object can be used to display a line of text
- It can also be used to display an image
- That is, a label can be composed of text, an image, or both at the same time

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Images

- The `ImageIcon` class is used to represent the image that is stored in a label
- If text is also included, the position of the text relative to the image can be set explicitly
- The alignment of the text and image within the label can be set as well
- See `LabelDemo.java`

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```
//********************************************************************
//  LabelDemo.java       Author: Lewis/Loftus
//
//  Demonstrates the use of image icons in labels.
//********************************************************************

import java.awt.*;
import javax.swing.*;

public class LabelDemo
{
   //-----------------------------------------------------------------
   //  Creates and displays the primary application frame.
   //-----------------------------------------------------------------
   public static void main(String[] args)
   {
      JFrame frame = new JFrame("Label Demo");
      frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

      ImageIcon icon = new ImageIcon("devil.gif");

      JLabel label1, label2, label3;

      label1 = new JLabel("Devil Left", icon, SwingConstants.CENTER);
```

continued

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continued

```
        label2 = new JLabel("Devil Right", icon, SwingConstants.CENTER);
        label2.setHorizontalTextPosition(SwingConstants.LEFT);
        label2.setVerticalTextPosition(SwingConstants.BOTTOM);

        label3 = new JLabel("Devil Above", icon, SwingConstants.CENTER);
        label3.setHorizontalTextPosition(SwingConstants.CENTER);
        label3.setVerticalTextPosition(SwingConstants.BOTTOM);

        JPanel panel = new JPanel();
        panel.setBackground(Color.cyan);
        panel.setPreferredSize(new Dimension(200, 250));
        panel.add(label1);
        panel.add(label2);
        panel.add(label3);

        frame.getContentPane().add(panel);
        frame.pack();
        frame.setVisible(true);
    }
}
```

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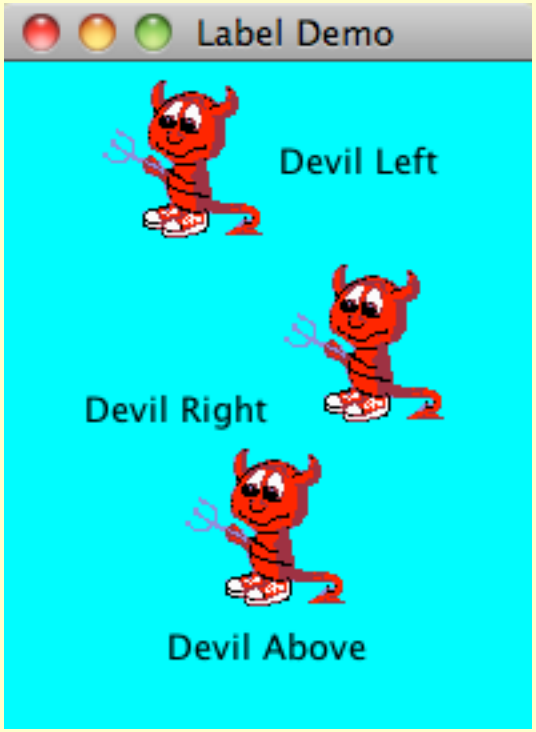
continued

```
        label2 = new JL                                    ingConstants.CENTER);
        label2.setHori                                     ants.LEFT);
        label2.setVerti                                    ts.BOTTOM);

        label3 = new JL                                    ingConstants.CENTER);
        label3.setHori                                     ants.CENTER);
        label3.setVerti                                    ts.BOTTOM);

        JPanel panel =
        panel.setBackgr
        panel.setPrefer                                    250));
        panel.add(label
        panel.add(label
        panel.add(label

        frame.getContentPane().add(panel);
        frame.pack();
        frame.setVisible(true);
    }
}
```



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Summary

- Chapter 3 focused on:
  - object creation and object references
  - the `String` class and its methods
  - the Java standard class library
  - the `Random` and `Math` classes
  - formatting output
  - enumerated types
  - wrapper classes
  - graphical components and containers
  - labels and images

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